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Pique et al.

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[54] **SUPERCONDUCTING GARNET THIN FILM SYSTEM**

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[*] Notice: This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

[63] Continuation-in-part of application No. 08/362,894, Dec. 23, 1994, Pat. No. 5,635,453.

[51] **Int. Cl.**[7] **H01L 39/02**; B05D 5/12

[52] **U.S. Cl.** **505/239**; 505/237; 505/238; 505/470; 505/474; 505/701; 505/729; 428/700; 428/701; 428/930

[58] **Field of Search** 505/237, 238, 505/239, 191, 470, 473, 474, 475, 476, 477, 482, 701, 702, 703, 704, 729; 428/688, 689, 700, 701, 702, 930

[56] **References Cited**

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5,229,360 7/1993 Shiga et al. .
5,418,215 5/1995 Tauber et al. 505/239
5,635,453 6/1997 Pique et al. 505/239
5,691,279 11/1997 Tauber et al. 505/239

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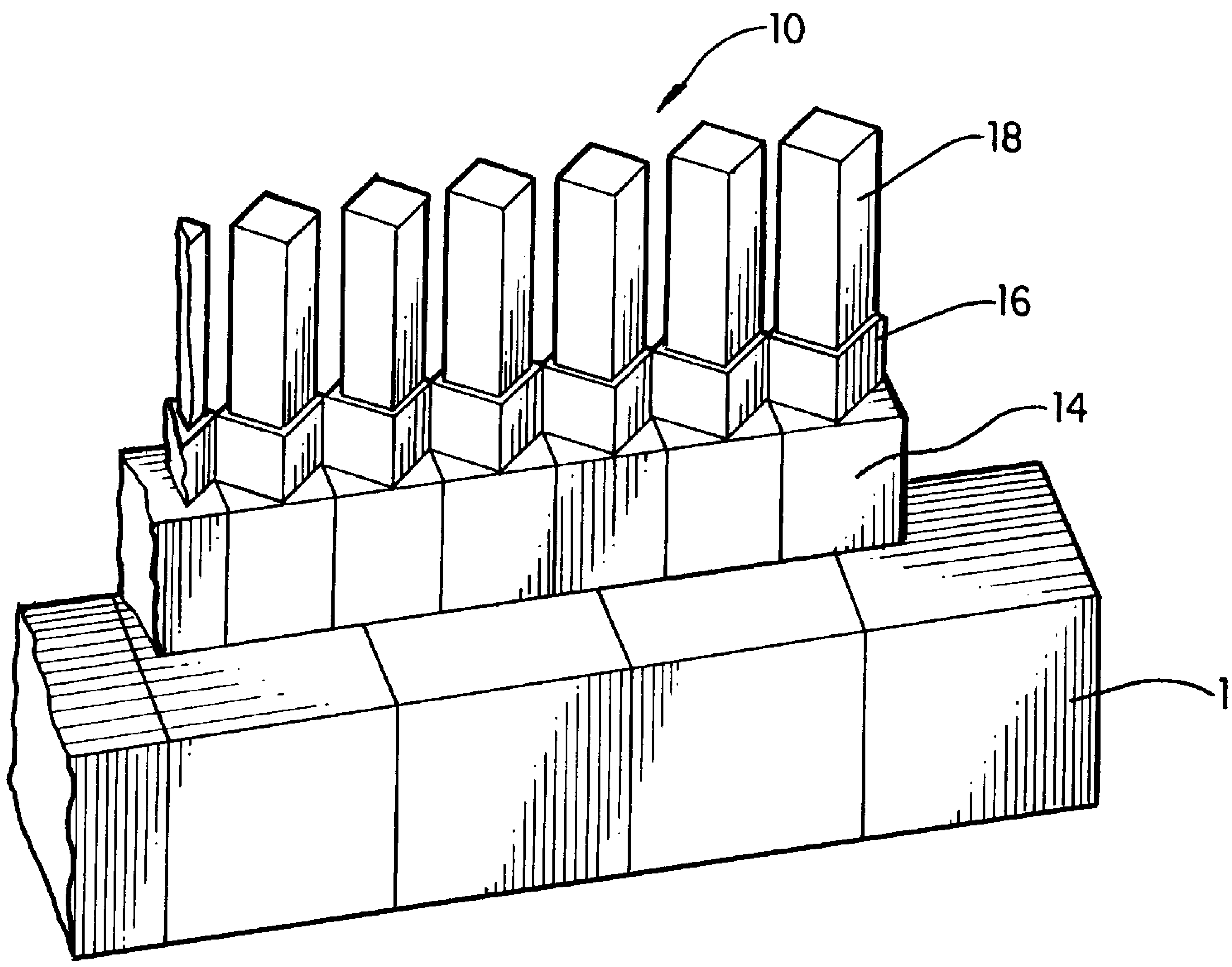
[57] **ABSTRACT**

A superconducting garnet thin film system (**10**) is provided for high frequency microwave applications where a single crystal high temperature superconducting (HTSC) layer (**18**) is integrated with a garnet substrate (**12**). A first perovskite compound buffer layer (**14**) is epitaxially grown on an upper surface of the garnet substrate layer (**12**) and defines a lattice constant less than the lattice constant of the garnet substrate layer (**12**) with the first perovskite layer being aligned in a cube on cube parallel orientation with respect to the garnet substrate layer (**12**). A second perovskite layer (**16**) is epitaxially grown on an upper surface of the first perovskite layer (**14**) at an orientation of 45° to first layer (**14**) and defines a lattice constant less than the lattice constant of the first perovskite layer. The HTSC layer (**18**) is epitaxially grown on an upper surface of the second perovskite layer (**16**) in parallel aligned orientation and is lattice matched to the second perovskite compound layer (**16**) for incorporation of passive components within the high temperature superconducting layer (**18**) having high frequency microwave applications.

22 Claims, 3 Drawing Sheets



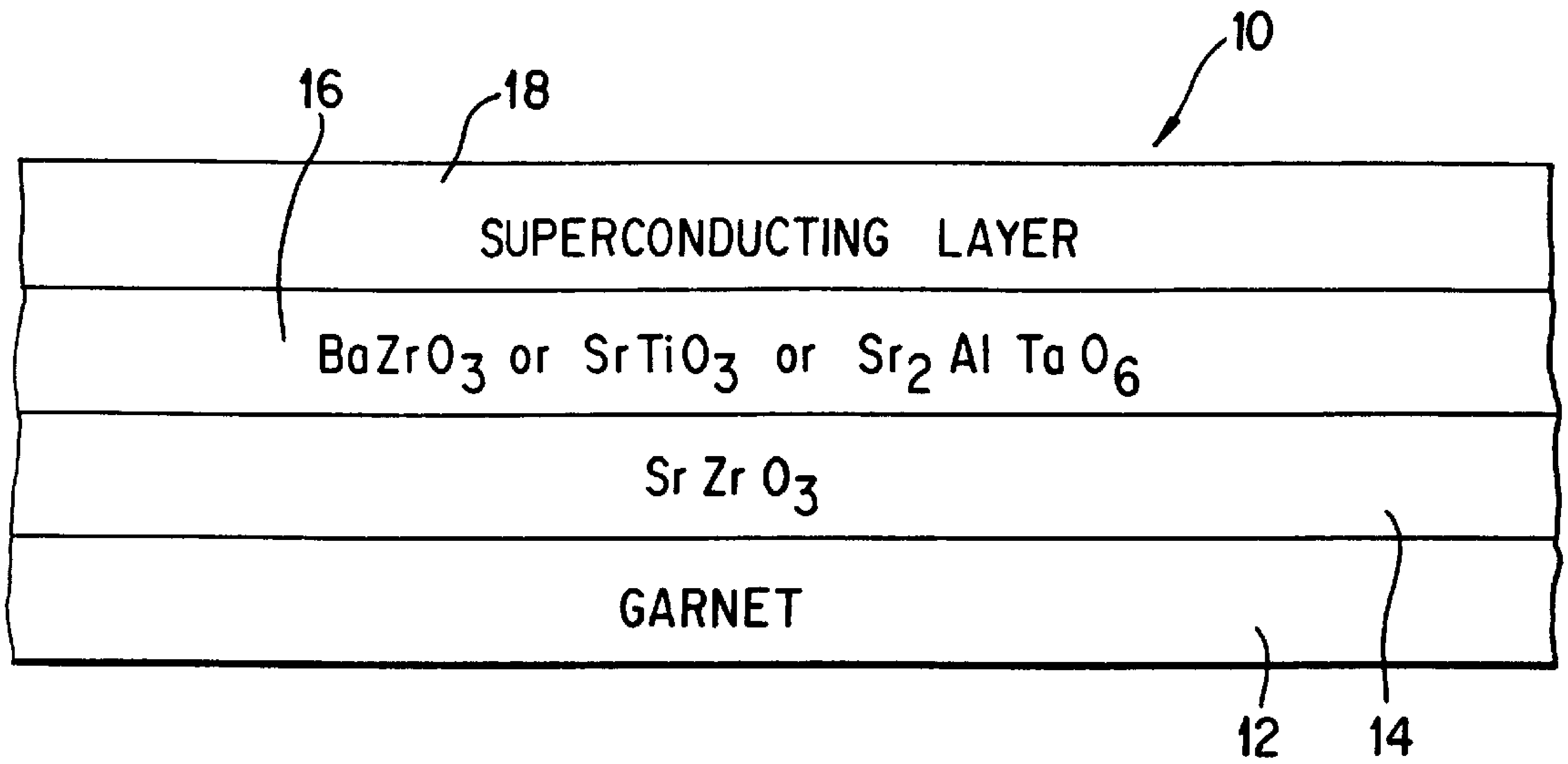

10
16
18
SUPERCONDUCTING LAYER
BaZrO3 or SrTiO3 or Sr2 Al Ta O6
Sr Zr O3
GARNET
12
14

FIG. 1

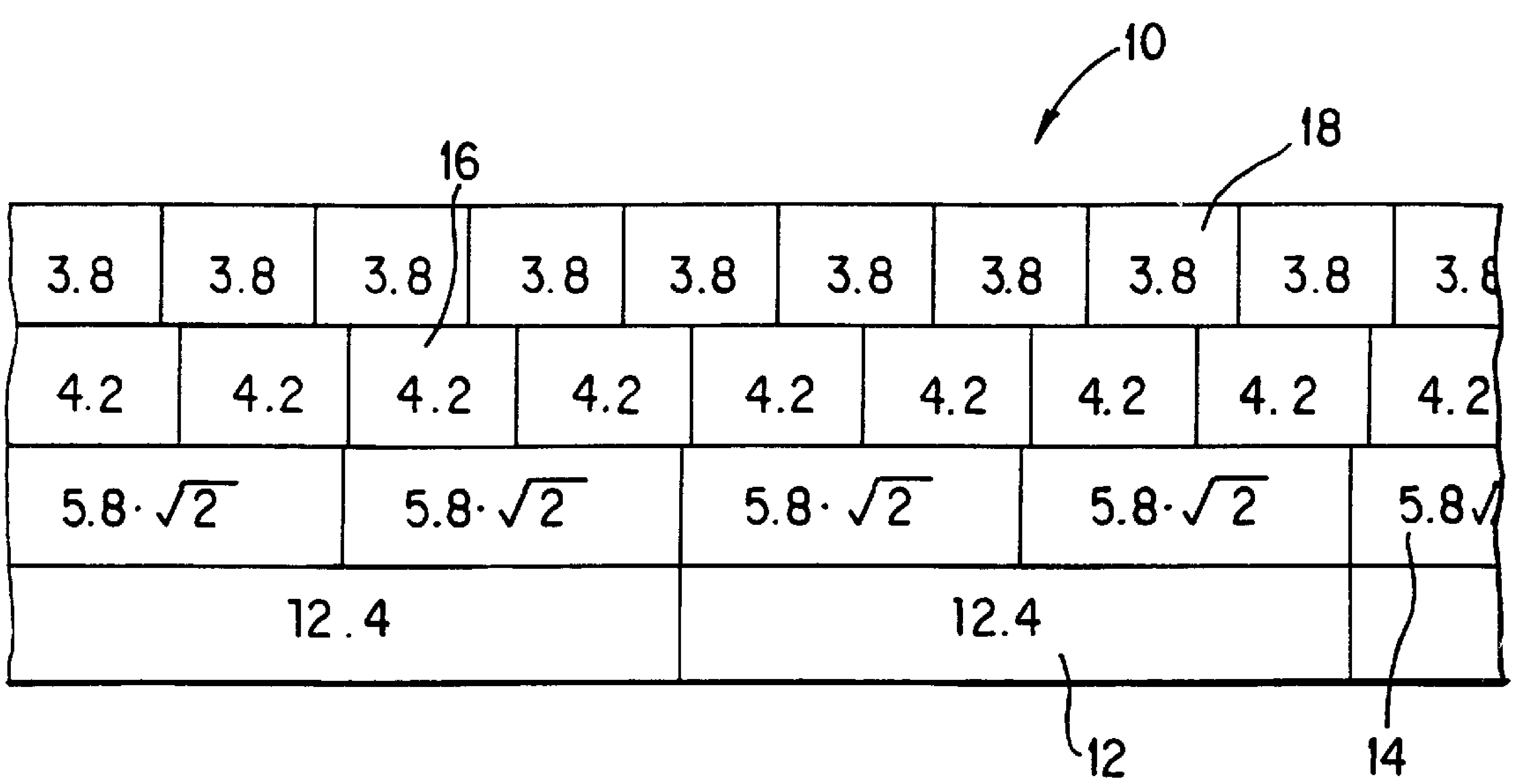

10
16
18
3.8
4.2
5.8·√2
12.4
12
14

FIG. 2

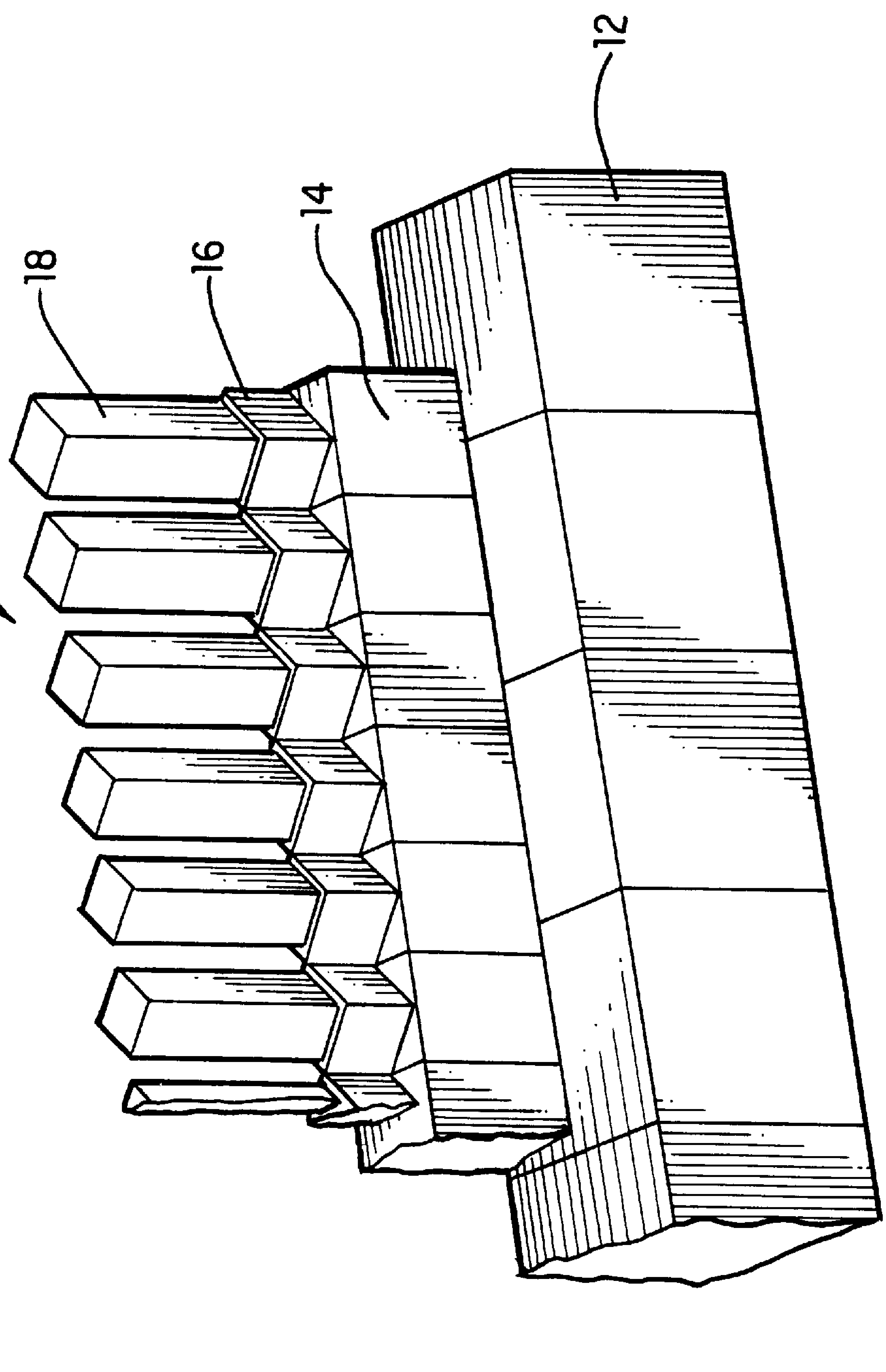


FIG. 3

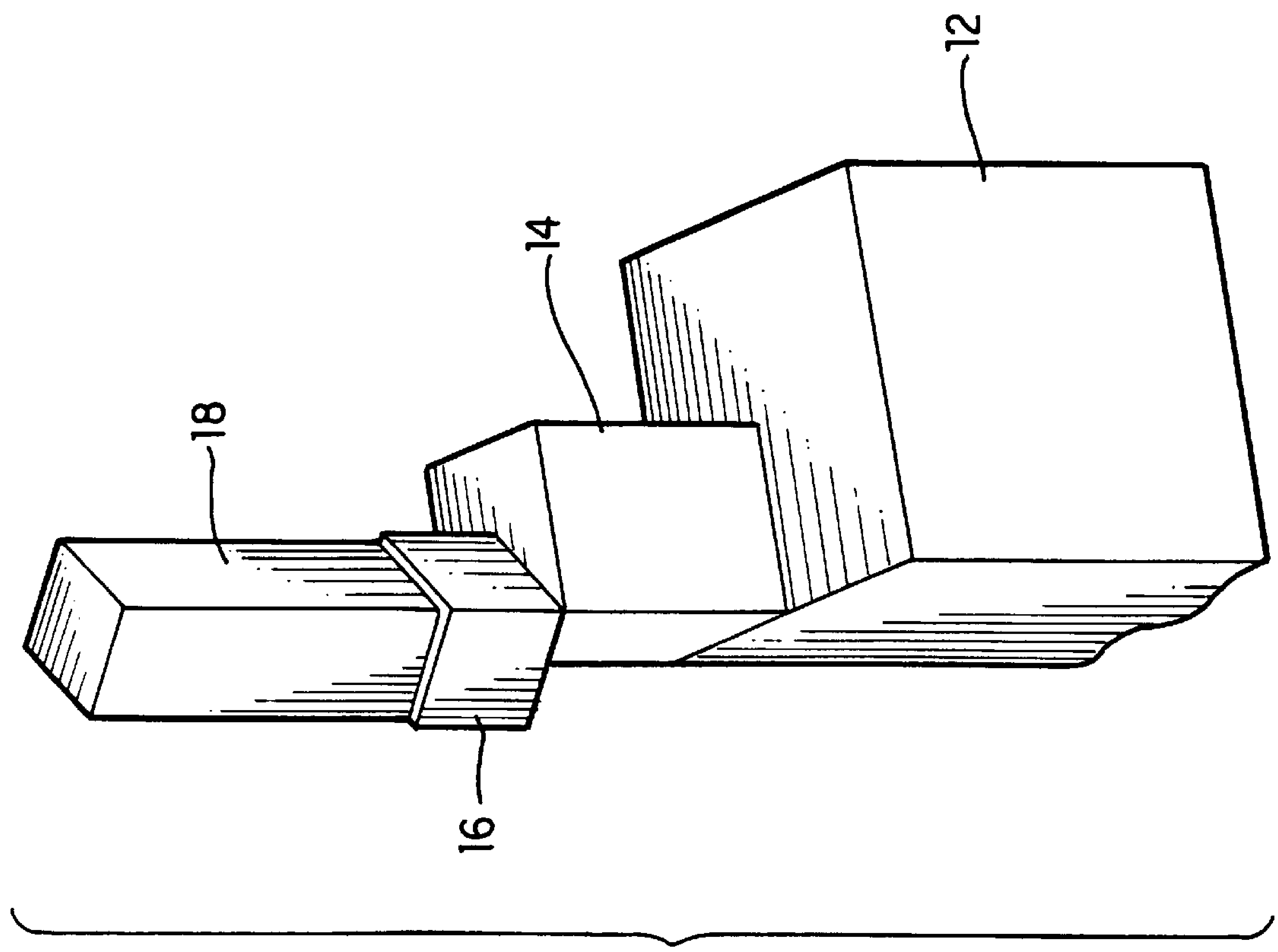


FIG. 4

SUPERCONDUCTING GARNET THIN FILM SYSTEM

REFERENCE TO RELATED PARENT APPLICATIONS

This Patent Application is a Continuation-in-Part of patent Application Ser. No. 08/362,894 filed on Dec. 23, 1994, now U.S. Pat. No. 5,635,453.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The garnet superconducting thin film system of the present invention relates to superconducting structures in combination with fabrication of such structures for general but not exclusive use in the high end micro-wave spectrum for particular application to satellite communications, cellular communications, radar and missile seeking devices which require higher frequencies in the millimeter wavelength region.

Such garnet structures are particularly useful for incorporation of passive microwave components incorporated within a high temperature superconducting layer (HTSC) with such components including resistors, capacitors, delay lines, filters, as well as a number of other electronic components. In particular, this invention pertains to superconducting thin film systems which provide for low microwave loss superconducting film integrated with garnet substrates. Still further, this invention relates to a garnet superconducting thin film system where a single crystal high temperature superconducting layer (HTSC) is integrated with a garnet substrate through a plurality of epitaxially grown and contiguously interfacing transitional buffer layers where the buffer layers provide for both (1) a lattice constant matching criteria between a lattice constant of the garnet substrate and the lattice constant of the high temperature superconducting layer, and, (2) a minimization of chemical reactions and diffusion between the substrate and the HTSC which has a deleterious effect on the superconducting properties. Surprisingly, it was found that certain perovskite compounds used as buffering layers provided a smooth lattice constant transition while minimizing the unwanted chemical reactions between the garnet substrate and the HTSC.

Further, this invention directs itself to a superconducting thin film system which provides for a garnet substrate having a lattice constant with a first epitaxially grown and contiguously interfacing perovskite compound buffer layer being deposited on an upper surface of the garnet substrate with the perovskite compound buffer layer having a lattice constant less than the lattice constant of the garnet substrate. Additionally, the superconducting thin film system includes a second perovskite compound buffer layer epitaxially grown and contiguously interfacing with an upper surface of the first perovskite buffer layer with the second perovskite compound buffer layer having a lattice constant less than the lattice constant of the first perovskite buffer layer and matched to or approximating the lattice constant of a single crystal high temperature superconducting layer deposited on an upper surface of the second perovskite buffer layer.

In order for superconducting films to be useful at higher frequencies, substrate dielectric losses must be reduced which requires a substrate such as garnet having a low dielectric constant, and low loss tangent. However, garnet substrates have a relatively large lattice constant and have been found to be generally incompatible for integration with high temperature superconducting layers. The subject superconducting thin film system provides a structure and method

of forming the same which integrates the garnet substrate layer with the high temperature superconducting film through a series of perovskite compound buffer layers which have monatonically decreasing lattice constant and are epitaxially grown on the garnet substrate and each to the other to provide an overall structure having a decreasing lattice constant throughout the layered system with a final perovskite layer having a lattice constant substantially matching the lattice constant of the high temperature superconducting film.

Additionally, this invention relates to a superconducting thin film system which provides for a garnet substrate having a predetermined lattice constant with a first perovskite compound layer grown in an epitaxial manner and contiguously interfacing with an upper surface of the garnet layer in a cube upon cube orientation growth with the orientation angles being substantially the same. Further, a second epitaxially grown perovskite compound layer is contiguously interfaced with an upper surface of said first perovskite compound layer with an orientation growth of approximately 45° between the first and second perovskite compound layers resulting in a differing orientation angle between the first and second perovskite compound layers. Finally, the HTSC layer is grown on the second perovskite compound layer in a cube on cube manner with substantially the same orientation.

2. Prior Art

High temperature superconducting thin films used in microwave components must be deposited on a microwave compatible substrate having a low dielectric constant and a low loss tangent to avoid unacceptable power dissipation in the substrate. High temperature superconducting thin films have been deposited on a variety of substrates including alkaline earth fluoride substrates with success. However, garnet substrates are of great importance and have found many uses in microwave applications due to their optimum magnetic properties. However, attempts to grow high quality, high temperature superconducting thin films on garnet substrates have generally proved unsuccessful due to the fact that the films which were produced were found generally to be polycrystalline and had relatively low superconductive transition temperatures, and poor microwave properties.

The main considerations dictating against the integration of high temperature superconducting films with garnet substrates are generally directed to (1) interfacial reactions between the garnet substrates and the high temperature superconducting films which are brought to the fore by the extremely high processing temperatures required for the growth of certain high temperature superconducting films; (2) a second consideration dictating against the integration of the high temperature superconducting films with a garnet substrate is due to the fact that there is a lack of lattice matching between the high temperature superconducting films which generally have a lattice constant approximating 3.8 Å to be grown on a garnet substrate having a lattice constant between 11.0–13.0 Å. This lattice mismatch dictates against the growth of highly oriented films, since a plurality of orientations are favored during the growth process.

By use of buffer layers formed of perovskite compounds grown between the garnet substrate and the high temperature superconducting film, it has been found that a lattice matching technique and structure is formed which allows for highly oriented structures to be formed. By specifically growing perovskite compound layers having diminishing lattice constants between the garnet sublayer and the high temperature superconducting film, a highly oriented thin film superconducting layer is formed which is highly useful for microwave applications in the high frequency microwave spectrum range.

Garnets, HTSC films, and perovskite compounds are known in the prior art. The basic problem in the prior art has been the combining of garnet substrates to HTSC films to form a superconducting film which is useful especially in microwave applications. Some prior art references have combined superconducting films with certain perovskite compounds and ceramic substrates, such as that shown in U.S. Pat. No. 5,159,413. However, such prior art does not address the problem of the subject Patent Application system since the ceramic substrate does not provide for the aforementioned properties of the garnet substrate particularly useful in microwave applications involving superconducting layers, but does not provide for the advantages and objectives of the subject system as herein described.

Other prior art systems, such as that described in U.S. Pat. No. 5,418,215 have tried to deposit or grow a superconductor film directly onto a garnet type substrate without any buffer layers, however, such a combination has been found to lead to a chemical reaction at the interface which has a deleterious effect on the superconductor layer impacting both on its structural and superconductive properties thus rendering such layer inadequate for microwave components.

Other prior art such as U.S. Pat. No. 5,229,360 provide for methods of forming particular multilayer circuits and in some cases use perovskite compounds in interfacing relationship but such do not direct themselves to the combination of buffering layers sandwiched between an HTSC and a garnet substrate for the purposes and objectives of the subject system.

SUMMARY OF THE INVENTION

This invention provides for a superconducting thin film system having a single crystal high temperature superconductor (HTSC) layer integrated with a garnet substrate. The film system includes a garnet substrate having a predetermined garnet substrate lattice constant and a single crystal HTSC layer having a predetermined HTSC layer lattice constant. A plurality of epitaxially grown and contiguously interfacing perovskite compound buffer layers are deposited between the garnet substrate and the HTSC layer. The perovskite compound layer grown or deposited on the garnet substrate has a lattice constant less than the garnet substrate lattice constant and is grown in a cube on cube aligned orientation. A perovskite compound layer having the HTSC layer grown thereon has a lattice constant substantially matching the HTSC and is grown on the first perovskite layer at an orientation approximating 45° each with respect to the other.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of the garnet superconducting thin film layer system showing a garnet substrate and a HTSC film layer integrated therewith by epitaxially grown perovskite compound layers;

FIG. **2** is a schematic diagram of the superconducting thin film system showing exemplary layer lattice constants of respective layers of the overall garnet thin film system;

FIG. **3** is a perspective diagram of the superconducting thin film system showing oriented layers; and,

FIG. **4** is a perspective, exploded view of a portion of the garnet superconducting thin film layer system showing crystalline orientation alignment between the first perovskite compound layer and the garnet substrate, approximately 45° crystalline orientation between the second perovskite layer and the first perovskite layer and crystalline orientation alignment between the second perovskite compound layer and the HTSC.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. **1–4**, there is shown garnet superconducting thin film system **10** for integration of high temperature superconducting layer (HTSC) **18** with garnet substrate **12** for particular use in microwave applications where electronic devices may be fabricated by the incorporation of components such as low loss passive networks, filters and other like devices into HTSC **18**. In the fabrication of microwave components, HTSC thin films are extremely useful; however, such must be deposited on substrates which are microwave compatible generally having a low dielectric constant as well as a low loss tangent in order to avoid unacceptable power dissipation in the substrate.

The HTSC layer **18** as referred to with respect to the inventive concept herein described includes compounds within the families of YBaCuO (YBCO), TBaCaCuO and BiSrCaCuO, as well as analogues thereof.

Garnet substrates **12** have been found to have acceptable microwave properties and generally low dielectric constants with an acceptable low loss tangent. However, in general, garnet substrates **12** have not been able to be used with HTSC layers **18** for a variety of reasons including a mismatch in the lattice constant between garnet substrates **12** (generally between 11–13 Å) and HTSC layer **18** (typically approximating 4.0 Å) which causes undesirable orientations between the substrate and the film, which results in the formation of grain boundaries which cause a reduction in current density and poor microwave performance, and disadvantageous interfacial chemical reactions between the HTSC layer **18** and the garnet layer **12** are created by a number of parameters including the high processing temperatures required for the growth of HTSC layer systems.

The object of this invention is to develop a garnet superconducting thin film system and fabrication technique for providing microwave compatible HTSC layers **18** integrated with garnet substrates **12** resulting in a unique building block for advanced microwave systems.

Garnet layer **12** is a mineral silicate class of compounds which are isometric in crystallization having a general chemical formulation $A_3B_5O_{12}$. Such particular garnet compounds where A is a rare earth element such as yttrium or gadolinium and B being either iron, gallium, or aluminum have been found to be particularly useful in providing the high quality microwave compatible HTSC layers **18** as herein described. Of particular importance are the yttrium gadolinium garnet (YIG), the gadolinium gallium garnet (GGG), and the yttrium aluminum garnet (YAG) having a cubic crystalline structure with acceptable microwave application parameters. Prior attempts to grow HTSC layers **18** on YIG, GGG or YAG layers **12** generally produced films that were not monocrystalline but rather polycrystalline having low superconductive transition temperatures which did not produce acceptable microwave application systems. Yttrium iron garnets have excellent magnetic properties for microwave applications and with the ability to grow an HTSC layer **18** on the YIG layer **12** would allow for fabrication of efficient microwave non-reciprocal devices and magnetically tunable microwave devices, minimizing the overall system space requirements which is of particular interest to the communications industry for on-board mounting on satellites or other space vehicles, and cellular communication stations.

HTSC layer **18** may be formed of yttrium barium copper oxide (YBCO) for use in trying to integrate such with garnet substrate layer **12**. However, YBCO layer **18** and garnet layer **12** have a large lattice constant mismatch. The cubic unit cell of the garnet layer **12** has lattice constants approximately ranging between 11.0 Å–13.0 Å and as compared to the YBCO layer **18***a–b* plane which has dimensions of a=3.82 Å and b=3.89 Å. Obviously, more than one orientation would be favored by this mismatch and microwave quality YBCO films **18** with one unique orientation cannot be grown on garnet substrates **12** under these conditions.

In accordance with the inventive concept as herein described, it was hypothesized that a plurality of epitaxially grown layers having gradually decreasing lattice constants and sandwiched between HTSC layer **18** and garnet substrate **12** could significantly reduce the lattice constant mismatch, and eliminate the chemical reaction between the HTSC layer **18** and garnet substrate **12**.

Thus, in order to attain a lattice constant transition between layer **12** and HTSC layer **18**, it has now been found that a class of compounds called perovskite compounds provide for a transitional lattice constant between layers **12** and **18** and is devoid of chemical reactions between the layers which allows for highly oriented single crystalline YBCO films **18** to be grown on garnet substrates **12**.

Perovskite compounds are minerals having a crystal structure which is ideally cubic and may occur as rounded cubes modified by octahedral and dodecahedral forms. The cubic nature of the perovskite compounds is useful in the epitaxial growth of such layers on garnet layer **12** as well as growth or deposition on each other.

Of particular importance, it has been found that certain perovskite compounds may be ideally used as transitional layers between substrate **12** and HTSC layer **18** to provide diminishing and non-obstructive lattice constant transitional values between garnet layer **12** and HTSC layer **18**.

It has been found that the perovskite compound $SrZrO_3$ (SZO) has an orthorhombic structure. The $SrZrO_3$ has lattice parameters approximating a=5.792 Å, b=5.818 Å, and c=8.189 Å. Layer **14** formed of the $SrZrO_3$ (SZO) has unit cells which when aligned in the [100] direction of the yttrium iron garnet (YIG) [100] plane provided for a mismatch of the unit cells approximating 13%.

SZO films were grown on both GGG and YIG substrates **12** in thickness ranges between 200–2000 Å. The films were epitaxially grown on substrate **12** and the film epitaxy was confirmed by both X-ray diffraction and ion beam channeling analysis. X-ray phi-scans reveal that the SZO [001] plane had grown in parallel manner to the YIG and GGG layer **12** [001] planes.

The SZO layer thus was grown in a cube on cube orientation with respect to garnet substrate **12** with what may be termed an aligned orientation as shown clearly in FIG. **4**.

The SZO layer **14** was deposited by pulsed laser deposition techniques at O_2 partial pressure of approximately 200 to 220 mTorr and a temperature of approximately between 750°–850° C. and YBCO film **18** was deposited on both the SZO—GGG and the SZO—YIG layers **12**. The HTSC film **18** was deposited with a thickness approximating 3000 Å and was deposited at an oxygen partial pressure of 220 mTorr and a temperature approximating 750° C. The combined resulting films **18** provided superconductive transition temperatures above 87 K however there was found to be an approximate mismatch of 7.3% between the YBCO film **18** and the SZO film **14**.

Although a reasonable quality microwave application system was found using an SZO layer **14** sandwiched between garnet layer **12** and YBCO layer **18**, in order to further reduce any mismatch between the perovskite layer **14** and the YBCO layer **18**, a further perovskite layer **16** investigation was initiated to still further lower any mismatch between the perovskite compound layer and the HTSC layer **18**.

The second buffer layer **16** investigation was based upon a search for a perovskite compound with lattice parameters between the SZO layer **14** and the YBCO layer **18**. The basic criteria was to find a perovskite layer **16** which could be grown epitaxially on first perovskite layer **14** and reduce the lattice constant mismatch between the second layer **16** and the YBCO layer **18**.

Lattice constants on the a, b plane between the approximate 5.8 lattice constant of layer **14** and the HTSC layer lattice constant 3.8 were made prime candidates for the second buffering layer **16**. $SrTiO_3$ (STO) having a lattice constant of approximately 3.9 Å and $BaZrO_3$ (BZO) having a lattice constant approximating 4.2 Å were selected to determine whether such were amenable to the epitaxial growth and fabrication of system **10**.

In both the cases of STO and BZO, the (001) plane was rotated by 45° along the normal to fit on the SZO **14** plane. The mismatch between the STO and SZO layers **12** and **14** approximated 7.1%. The mismatch between the BZO layer **16** and SZO layer **14** approximated 3.1%. Films of the compounds STO and BZO were deposited to a thickness of 500 Å and were deposited at 750° C. with a partial oxygen pressure of 220 mTorr. Film epitaxy for both STO and BZO and plane rotation was confirmed through X-ray phi-scans.

Thus, the STO and/or BZO layers were grown at an orientation of approximately 45° with respect to first perovskite compound layer **14** as shown in FIG. **4**. As further seen in FIGS. **3** and **4**, HTSC layer **18** is grown on layer **16** in a matching or aligned orientation similar to the aligned cube on cube growth between layer **14** and garnet substrate layer **12**.

YBCO films **18** were deposited on both the STO and BZO layers **16** and provided transition temperatures greater than 88 K with transition widths being less than 0.5 K. The superconductive film properties using the second layers of STO and BZO **16** was more pronounced for films grown on YIG substrates **12** than GGG substrates **12** due to an improved diffusion barrier resulting from the two buffer combination.

In overall concept, it has now been found that a superconducting thin film system **10**, particularly useful in microwave applications, may be formed by integrating superconducting layer **18** with garnet substrate **12** through means of a plurality of buffering layers such as layers **14** and **16**. The buffering layers **14** and **16** must be epitaxially grown to substrate **12**, to each other, and to superconducting layer **18**. A particular class of compounds called perovskite compounds have been found useful in fabricating system **10** since such are approximately cubic in nature and can be interfaced with substrate **12** and layer **18** in an epitaxial relationship. Additionally, particular perovskite compounds have been chosen to allow for a transitional diminishment of the lattice constant between the garnet substrate **12** and the superconducting layer **18**. In this manner, the superconducting layer **18** may be epitaxially grown on a top buffering layer **16** with a minimal lattice constant mismatch resulting in highly oriented films being grown.

In the method of forming superconducting thin film system **10** garnet substrate **12** is initially established which has a garnet substrate lattice constant generally between 11 Å and 13 Å. In one form of the invention concept, a perovskite compound buffer layer **14** is epitaxially grown on a garnet substrate with the perovskite compound buffer layer **14** having a lattice constant less than the garnet substrate lattice constant. A high temperature superconducting layer **18** is epitaxially deposited on the perovskite compound buffer layer **14** with the high temperature superconducting layer **18** having a lattice constant less than the lattice constant of the perovskite compound buffer layer **14**. In this manner, there is a transition between the relatively high lattice constant of the substrate **12** and the relatively low lattice constant of the superconducting layer **18**.

The perovskite compound layer **14** is pulse laser deposited on an upper surface of the garnet substrate in an environment approximating a temperature of 750° to 800° C. with an oxygen partial pressure approximating 200 mTorr. The established garnet substrate layer **12** may be selected from the group consisting of YIG, GGG or YAG. Additionally, the perovskite layer **14** compound may be formed of $SrZrO_3$. Use of this perovskite compound results in a transitional layer having a lattice constant approximating 5.8 which is a lattice constant nested between the lattice constant of layers **12** and **18**.

In order to further diminish any mismatch between superconducting layer **18** and a last buffering layer of a perovskite compound, additional transitional buffering layers may be incorporated into the fabrication of system **10**. Initially, garnet substrate **12** is established and a first perovskite compound buffer layer **14** is epitaxially grown on an upper surface of garnet substrate **12**. First perovskite compound buffer layer **14** has a lattice constant less than the garnet substrate lattice constant to provide a first transitional buffering layer. A second perovskite compound buffer layer **16** is sequentially and epitaxially grown on an upper surface of first perovskite compound layer **14** with the second perovskite compound buffer layer **16** having a lattice constant less than the first perovskite compound buffer layer lattice constant. Finally, high temperature superconducting layer **18** is epitaxially deposited or grown on second perovskite compound layer **16** with the high temperature superconducting layer **18** having a lattice constant approximating the lattice constant of the second perovskite compound layer lattice constant. In this manner there is a more gradual decrease or transition from one layer to another layer within overall system **10** and a mismatch of the lattice constant between upper perovskite compound layer **16** and HTSC layer **18** may be further minimized.

The first perovskite compound layer **14** may be pulse laser deposited on substrate **12** and second perovskite compound layer **16** similarly may be pulse laser deposited on first perovskite compound layer **14**. Finally, HTSC layer **18** may similarly be pulse laser deposited on an upper surface of second perovskite compound layer **16**.

Additionally, in order to provide the transitional lattice constants, first perovskite compound layer **14** may be formed of $SrZrO_3$ with second perovskite compound layer **16** being selected from the group consisting of $BaZrO_3$, $SrTiO_3$, or Sr_2AlTaO_6.

Although this invention has been described in connection with specific forms and embodiments thereof, it will be appreciated that various modifications other than those discussed above may be resorted to without departing from the spirit or scope of the invention. For example, equivalent elements may be substituted for those specifically shown and described, certain features may be used independently of other features, and in certain cases, particular locations of elements may be reversed or interposed, all without departing from the spirit or scope of the invention as defined in the appended claims.

What is claimed is:

1. A garnet superconducting thin film system having a single crystal high temperature superconducting layer (HTSC) integrated with a garnet substrate comprising:

(a) a garnet substrate having a predetermined garnet substrate lattice constant;

(b) a single crystal HTSC layer having a predetermined HTSC lattice constant; and,

(c) a plurality of epitaxially grown and contiguously interfacing perovskite compound buffer layers deposited between said garnet substrate and said HTSC layer, a first of said perovskite compound buffer layers having a lattice constant less than said garnet substrate lattice constant and grown on said garnet substrate in a cube on cube orientation, a second of said perovskite compound buffer layers having a lattice constant less than said lattice constant of said first perovskite compound buffer layer and grown on said first perovskite compound layer at an orientation approximating 45° each with respect to the other, said second of said perovskite compound buffer layers having a lattice constant substantially matching said HTSC lattice constant.

2. The garnet superconducting thin film system as recited in claim **1** where one of said perovskite compound layers is formed of a compound having a formula $AZrO_3$ where A is an element from the group consisting of barium or strontium.

3. The garnet superconducting thin film system as recited in claim **1** where said second perovskite compound layer is formed from the group consisting of barium zirconate or strontium titanate.

4. The garnet superconducting thin film system as recited in claim **1** where said HTSC layer is selected from the group consiting of YBaCuO (YBCO), BiSrCaCuO and TBaCaCuO.

5. The garnet superconducting thin film system as recited in claim **4** where said YBCO superconducting layer has a lattice constant approximating 3.8 Å.

6. The garnet superconducting thin film system as recited in claim **1** where said garnet substrate is a garnet compound having the formula $A_3B_5O_{12}$,

where:

A=a rare earth element

B=iron, gallium, or aluminum

O=oxygen.

7. The garnet superconducting thin film system as recited in claim **6** where said rare earth element is an element from the group consisting of yttrium or gadolinium.

8. The garnet superconducting thin film system as recited in claim **6** where said garnet compound has a lattice constant within the range between about 11 and about 13 Å.

9. The garnet superconducting thin film system as recited in claim **6** where said first of said perovskite layers is formed of $SrZrO_3$, having a lattice constant approximating a dimension defined by each of the dimensions: a=5.814 Å, b=5.799 Å and c=8.196 Å.

10. The garnet superconducting thin film system as recited in claim **6** where said second of said perovskite layers is formed of $BaZrO_3$ having a lattice constant approximating 4.2 Å.

11. The superconducting garnet thin film system as recited in claim **6** where said second of said perovskite layers is formed of $SrTiO_3$ having a lattice constant approximating 3.5 Å.

12. The superconducting garnet thin film system as recited in claim **6** where said second of said perovskite layers is formed of Sr_2AlTaO_6 having a lattice constant approximating 7.6 Å.

13. A method of forming a garnet superconducting thin film system including the steps of:

(a) providing a garnet substrate having a predetermined garnet substrate lattice constant;

(b) epitaxially growing in cube on cube relation, a perovskite compound buffer layer on said garnet substrate, said perovskite compound buffer layer having a lattice constant less than said garnet substrate lattice constant; and,

(c) epitaxially depositing a high temperature superconducting layer (HTSC) on said perovskite compound buffer layer, said HTSC layer having a lattice constant less than said lattice constant of said perovskite compound buffer layer.

14. The method of forming a garnet superconducting film system as recited in claim **13** where the step of epitaxially growing said perovskite compound buffer layer includes the step of pulse laser depositing said perovskite compound buffer layer on an upper surface of said garnet substrate.

15. The method of forming a garnet superconducting film system as recited in claim **14** where the step of pulse laser depositing includes the step of establishing a pulse laser deposition environment of approximately 750°–800° C. and an oxygen partial pressure approximating 200–220 mTorr.

16. The method of forming a garnet superconducting thin film system as recited in claim **15** where said garnet substrate is selected form the group consisting of yttrium-iron-garnet, gadolinium-gallium-garnet, or yttrium aluminum garnet.

17. The method of forming a garnet superconducting thin film system as recited in claim **16** where said perovskite layer compound is $SrZrO_3$.

18. The method of forming a garnet superconducting thin film system including the steps of:

(a) establishing a garnet substrate having a predetermined garnet substrate lattice constant;

(b) epitaxially growing in cube on cube relation, a first perovskite compound buffer layer on said garnet substrate, said first perovskite compound buffer layer having a lattice constant less than said garnet substrate lattice constant;

(c) sequentially epitaxially growing a second perovskite compound buffer layer on said first perovskite compound buffer layer, said second perovskite compound buffer layer having a lattice constant less than said first perovskite compound buffer layer lattice constant, said second perovskite compound buffer layer being grown at substantially a 45° orientation to said first perovskite compound buffer layer; and,

(d) epitaxially depositing a high temperature superconducting (HTSC) layer on said second perovskite compound layer, said high temperature superconducting layer having a lattice constant approximating said lattice constant of said second perovskite compound layer lattice constant.

19. The method of forming a garnet superconducting thin film system as recited in claim **18** where the steps of (b), (c), and (d) include the steps of pulse laser depositing a respective layer on a preceding layer.

20. The method of forming a garnet superconducting thin film system as recited in claim **18** where said garnet substrate is selected from the group consisting of yttrium-iron-garnet, gadolinium-gallium-garnet or yttrium aluminum-garnet.

21. The method of forming a garnet superconducting thin film system as recited in claim **18** where said first perovskite compound layer is $SrZrO_3$.

22. The method of forming a garnet superconducting thin film system as recited in claim **18** where said second perovskite compound layer compound is selected from the group consisting of $BaZrO_3$, $SrTiO_3$, or Sr_2AlTaO_6.

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